Sandia National Laboratories

MFG S&T Quarterly

MFG Science & Technology That Makes a Difference

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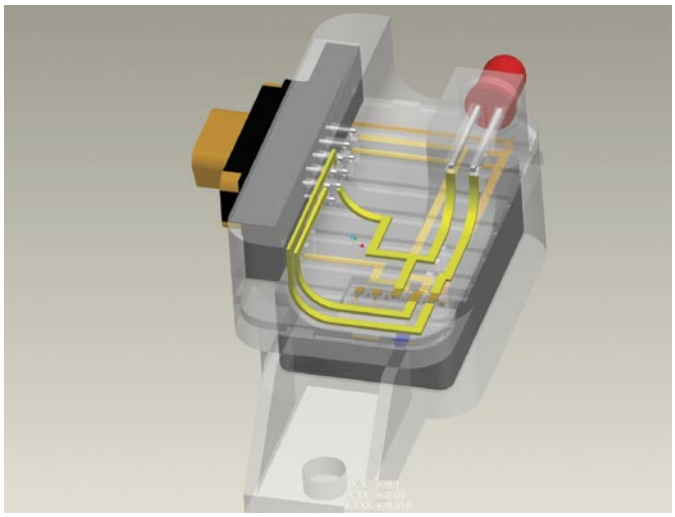
Pioneering Direct Write Technology

Sandia's Manufacturing Engineering and Process Development Dept. is pioneering Direct Write (DW) technology in integrated rapid manufacturing. The latest three-dimensional DW machines, such as the nScrypt 3De™ system used at SNL, dispense conductive inks and other material suspensions from a multi-axis robotic nozzle with precise control of flow and stopping point. More importantly, they have the capability of writing features on the order of 50 micrometers on contoured substrates of various materials and geometries. In a typical operation, surface contours are laser scanned and the data subsequently stored for write path planning. Ink conductivity is suitable for electronic applications following a post-process anneal. Recently, multi-layer connectivity in integrated DW and stereolithography smart structures has been demonstrated. One such smart structure is shown **at right**. In this example, a multi-functional module was created that features three-dimensional interconnected electronics (including input micro-miniature D connector and DC-DC converter) to power a simple LED circuit. Interconnect is fabricated by introducing DW circuitry in multiple layers of a stereolithography build.



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New Non-Contact Inspection Capabilities

The Manufacturing Processes & Services Department has acquired a Taylor-Hobson Talysurf CCI 3000Å 3D non-contact surface profiler for measurement of micro-roughness and step heights. It is capable of acquiring three-dimensional pointclouds of small artifacts.

The Coherence Correlation Interferometer (CCI)is valuable in the measurement of super-polished optical components, semiconductor, MEMS and other applications requiring high precision 3D profile analysis. Talysurf CCI 3000 provides non-contact 3D measurement with 0.1Å (10pm) resolution.

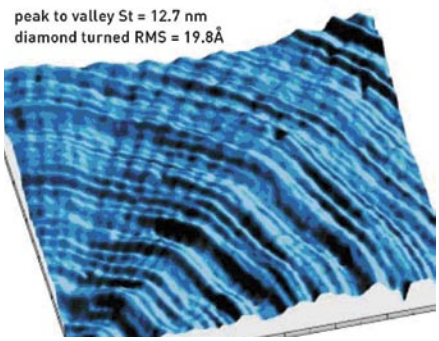
High data resolution in X and Y axes combined with low missing data rate contribute to system performance.

- 0.1Å vertical resolution
- 0.36µm lateral resolution
- 1,048,576 data points
- 0.03Å Surface Repeatability (RMS Z)

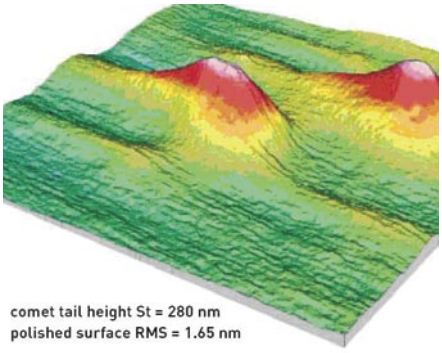
The instrument combines the surface imaging quality of a microscope with the high accuracy measuring capability of a surface profiler. The result is a 3D surface texture, step height and micro-dimensional measurement system that gives results in seconds.

Polished, rough, specular or diffuse components having reflectivity between 0.3% and 100% can be analyzed. Material types including glass, metal, photoresist, polymer, liquid inks and pastes can be measured.

Artifacts traceable to international standards are used to calibrate the instrument in both the vertical and lateral measurement axes. Therefore the geometrical, dimensional and surface characteristics of any known artifacts can be reproduced with authority and confidence. **Inspection, Continued page 3**



Micro-roughness, waviness, feed rate and depth of cut on diamond turned surfaces can be evaluated.



Surface texture (RMS) to sub-angstrom levels can be measured on super-polished optical components.

Tech Updates

Summer Research Interns Produce Significant Contributions

Sandia's Mfg. S&T Center annually employs a number of students who conduct research with mentors. This is a report on some of the results the summer interns have achieved. Part II, in the November issue, will present the research of two other interns on the subjects of retinal implants and thermal protection systems for hypersonic flight vehicles.

Students Create Hadamard Masks Utilizing Microstereolithography Capability

Larinn Southwell and Chris Robinson, mentored by Jeremy Palmer and Bart Chavez of Manufacturing Engineering and Process Development, have created a Hadamard mask utilizing the organization's new microstereolithography capability. Using microstereolithography, a form of additive rapid prototyping, optics developers have the freedom to integrate mounting and positioning structures directly into an optical mask assembly.

Computer Model of Hadamard Mask Created By Microstereolithography

Microstereolithography is an additive process in which solid objects are built out of UV curable liquid polymer. This polymer solidifies as the UV laser draws out the first layer (100µm) of the object. The platform then moves down another 100µm and the laser draws the second layer of the part. An object is built layer by layer from the bottom up, therefore having the ability to take on any shape. This additive layer process also allows other items to be integrated into the object by stopping the build half way through, placing the item and then continuing the building process around the item placed.

This eliminates the need for assembly and fasteners. Through the use of the Sony SCS 6000 stereolithography apparatus (SLA), features sizes as small as 75µm and larger than 300mm can be created in the same build. Chris and Larinn designed and built a Hadamard optical mask using microstereolithography that integrates the mounting structure directly onto the mask. Hadamard masks are used in spectrometry to create a defined signal with a high signal to noise ratio (SNR).

The Hadamard mask being created has slits and solidified strips of 150µm or larger (see figure, left). Due to laser over cure and other parameters, adjustments were made iteration by iteration until appropriate mask tolerances were met. At the CAD level the mounting structure and/or the mask can be modified to meet specific needs. A conceptual design of an entire positioning system that integrates all the components necessary for one compact optical spectrometry system made with SLA is underway.

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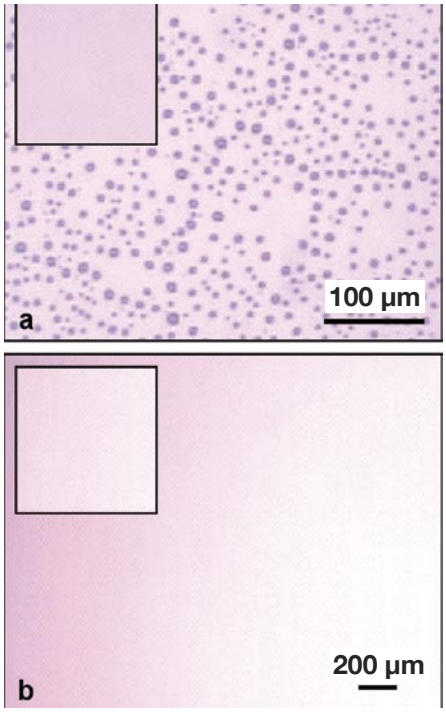
Eliminating Polymer Dewetting Using Nanoparticles

Melissa Homes of Michigan State University conducted the following research:

Thin polymer films are used in many new and emerging technologies, including dielectric coatings, fuel cells, nanolithography resist layers and chemical and biological sensors. Application of these films requires that they be of uniform thickness and remain stable on substrates. However, due to a difference in surface energies, the polymer may dewet from the substrate, rendering the device useless.

One specific area where this has been seen is in the development of chemical sensors, such as surface acoustic wave sensors or SAWs. For this type of sensor, a polymer film designed to selectively absorb a specific chemical agent is spray-coated onto a quartz substrate. The device is tested by exposing it to various vapors of biochemical agent surrogates. Upon exposure, the polymer film is often seen to dewet, or bead up on the substrate (Fig. 1a, above).



Optical micrographs of spin-cast polystyrene (PS) films on a silicon wafer exposed to a saturated toluene atmosphere show film prior to annealing (same scale bar). (a) Pure PS film after exposure for 50 minutes. (b) PS with 3% by mass fullerenes after exposure for 3 hours. Films are 33 nm thick.

We have found that the addition of nanoparticles such as fullerenes to the polymer film eliminates dewetting upon exposure to vapors (Fig. 1b, above). The nanoparticles segregate to the polymer-substrate interface upon manufacture where they form a nanoparticle-rich layer. This layer prevents the polymer from dewetting, allowing the film to remain stable, even under adverse conditions. This phenomenon has been seen for a variety of polymers, leading to its use in numerous applications. Also, because only a minute amount of nanoparticles are needed for these thin (< 100 nm) films, their overall cost is not prohibitive to their utilization.

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Enhanced Thermal Interface Materials

John Macha submitted ths report on his summer research:

As electronic assemblies have become more compact, efficient transfer and dissipation of heat has become increasingly difficult. Thermal interface materials (TIMs) are commonly used to improve heat transfer between a heat producing component and a heat spreader or heat sink. However, conventional TIMs often do not achieve their full potential because of high thermal resistances at the TIM/substrate interfaces.

The Organic Materials Department is researching the source of high interface thermal resistance in TIM bondlines and how to apply this knowledge to develop enhanced thermal interface materials. My work this summer focused on particle-depleted TIM regions—one of the potential causes of the poor thermal transport at the TIM interfaces. To determine the significance of these depleted regions, I spin coated unfilled epoxies of different thicknesses onto aluminum substrates. Then, by using laserflash analysis to calculate the thermal diffusivity of the samples, I determined the thermal conduction of the various samples.

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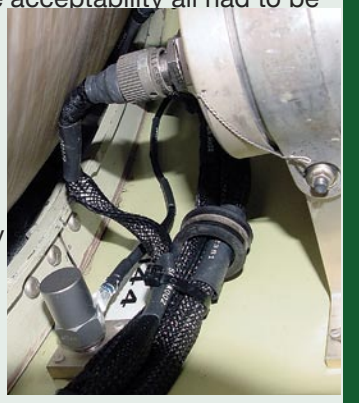
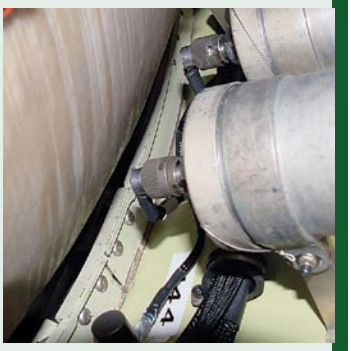
Rapid Response for Flight Systems

On Thursday, Feb. 27th at about 7:00 am, Anthony Montoya, Electronic Fabrication Dept. Project Lead, was notified by the management of a Sandia missile launch department that two flight-qualified cables were critical to meet scheduled testing deadlines at the Kodiak, Alaska launch facilities.

Missile launch management would be flying out to Kodiak at 6:00 am the following morning and expected to have these cables in hand. Design review with engineers, fabrication including 8 hours of curing time for potting material, pre-pot and post-pot inspection and quality assurance acceptability all had to be completed in a total of 19.5 hours.



This left the Electronic Fabrication team minimal time for rework but no time for complete rebuilds. Rosa-Linda Vargas and Lin Nguyen were the main fabricators of the cables; James Randolph helped Lin with the grounding of one cable. The cables were fabricated by 4 pm the same day, fully pre-pot inspected by Tracy Lovato and Therese Borrego, and accepted with complete inspection reports by Debbie Duran by 5pm.



Lin and Rosa designed and fabricated back shell potting molds for the Tra-Cast material, and potted the cables by 5:30 pm. Eight hours later, Tra-Cast cure time, Tracy Lovato and Debbie Duran arrived at 1 am on Friday to perform the post-pot inspection and quality assurance acceptability. When they arrived they noticed that one of the connectors of the cables had leaked and required re-work. Rosa was called in at 1:15 am to perform the re-work. The post-pot inspection and acceptance was completed by 2:45 am.

The fabricators and inspectors went home and Anthony Montoya stayed until 4:30 am to hand over the cables to the deputy director, who hand carried these cables to Kodiak, Alaska on a 6 am flight. The pictures **at right** show the cable assemblies before and after the anomaly. As a follow-up to the rapid response, a special thanks including breakfast, presentation, and a framed picture was given to the Electronic Fabrication department.

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Inspection, Continued from Page 1

Components up to 300mm x 300mm in size and specimen areas up to 7.2mm x 7.2mm can be measured without stitching. Height adjustment of 200mm allows inspection of parts held in processing jigs, vacuum chucks, or other fixtures.

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Optical Specifications for Various Magnifications

Magnification	X2.5	X5	X10	X20	X50
Numerical Aperture	0.075	0.13	0.3	0.4	0.55
Working Distance(mm)	10.3	9.3	7.4	4.7	3.4
Optical Resolution(mm)	7.2	3.6	1.8	0.9	0.4-0.6* surface dependent
Maximum Slope (degrees)	2.0	4.0	7.7	14.6	27.7
Measurement Area(mm)	7.2x7.2	3.6x3.6	1.8x1.8	0.9x0.9	0.36x0.36
Lateral Sampling Resolution (mm)	7	3.5	1.75	0.88	0.35

New Permanent Center 2400 Employees

Welcome to our new employees who joined in the July time frame.

2451	Mabel Pecos
2452	Marlene Chavez
2452	James Kuthakun
2452	Richard A. Sanchez
2452	Timothy Turner
2453	G. Craig Clark
2454	Audrey Gallegos
2454	Ray Hannah
2454	Brenda Pentecost

Gel Capacitor, Active Ceramics Win Defense Programs Award of Excellence

In FY05, the Gel Capacitor Product Realization Team has provided critical support for the NW SMU. In collaboration with other manufacturing centers, team members within the Mfg. S&T Center carried out science-based research, development, and prototyping activities. Partnering with the Dow Corning Corporation has allowed the development of new silicone gels to meet the rigorous environmental and aging requirements for weapons components, while collaborations with Columbia University, Cornell University, and Northwestern University have provided a fundamental understanding of material behavior and failure mechanisms. Gel capacitor production equipment was also designed and fabricated within the Center. The gel development and equipment prototyping operations in the Center have allowed for rapid product realization, as well as successful transfer of the process to an external vendor.

The successful development of a new silicone gel reduced the risk associated with gel capacitor product realization and resulted in the team being awarded an Employee Recognition Award. Once online, Center-designed production equipment allowed fabrication and qualification of prototype gel capacitors, enhancing the producibility of the components and removing the gel capacitor from the NW SMU's list of components at risk. As a result, the NNSA selected the Gel Capacitor Development Team as a recipient of the Defense Programs Award of Excellence for CY2004. This award reflects the team's commitment to success and Center's customer focus.

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The Active Ceramics Production Team is being recognized by NNSA Defense Program for their significant achievement of increased efficiency gained through incorporation of lean/six sigma methodology.

These changes resulted in a significant reduction of touch labor time required to build an active ceramic components set for the Neutron Generator Program when compared to the prior years with these lean/six sigma improvements. The overall product cost for the MC4380A Neutron Generator was reduced significantly per unit as a result of these improvements for active ceramic components. These improvements have increased production capacity without adding additional cost to the customers.

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Update on Active Ceramics Construction Project

The Active Ceramics construction project involves expansion and remodeling within and outside of the Ceramics and Glass Vault-Type Room (VTR), as well as the Plastics Lab in Building 878. The completion of this part of the project means that the contractors will be performing the remainder of their work outside of the VTR. This part of the project had a significant impact on employees and business operations and was important because of the difficulty in acquiring escort services. Active Ceramics provided personnel to act as escorts to fill this need and to minimize any delays in construction activities.

Summit Construction, the primary contractor on this project, is engaged in a very aggressive construction schedule. Center management anticipates this project will be completed at the end of this fiscal year. Once the new walls are installed the construction area will become significantly busier with all of the sub-contractors working on site at the same time.

With this increased activity there will be a need for all building 878 occupants to be cautious. The potential for accident or injury will increase as more contractors move materials and equipment in and out of the construction site. I am asking all building occupants to be aware of their surroundings and be alert to any unsafe activities or conditions as well as security issues. If anyone sees any unsafe work practices or security violations or concerns, please notify Chris Armijo @ 284-2579.

Technologist House Calls

In 1999 The Mfg. S&T Center initiated its Technologist House Calls Program. "House Calls" are offered once a year and give technologists the opportunity to meet with a Center manager, other than their own, to show them their lab and discuss the nature of their work. This program allows mangers to become familiar with the capabilities and expertise of technologists within the Center. Participation in this program is mandatory for all Center managers, but voluntary for the technologists. This year 17 of the 38 technologists from the Center participated in the program. From 1999 to the present, technologist's participation in this program has averaged about 50%.

Phil Gallegos, Electronics Fabrication manager, visits with Eric Jones Jr. of Thin Film, Vacuum and Packaging Dept.

During the three years that I have been a technologist in the Mfg. S&T Center, I have participated in the House Calls Program each time it was offered and each time found it to be a pleasant experience. Throughout my 23 years as a technologist at Sandia I have never heard of another department that offers a similar program. One advantage I have experienced from this program has been the referral of new customers by managers who are now aware of the analytical services I provide. I encourage all Center technologists to participate in this program.

Thanks Phil and Eric for the photo, and to Carter Hodges and Bob Poole (both of the Thin Film, Vacuum and Packaging Department) for providing me with the statistics and historical information for this program.

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6S Concepts Making Process Improvements In The Magnetics Laboratory

6S tools have helped change the culture of the Magnetics lab to fall in line with Mfg. S&TCenter ISO goals. 6S stands for Sort, Straighten, Shine, Standardize, Safety, and Sustain. The Magnetics lab, currently housed in 840/265, will be moving to 878/A1000 in the Fall of 2005. In order to keep up with the demands of the business with the resources available the Electronic Fabrication Department decided to implement a process engineering event that would streamline this move. This event would also address improvement in operational performance in the areas of organization, workflow, capacity, and efficiency.

Members of the 6S Team included (L to R) Seyfred Toledo, Kenny Gutierrez, Ricco Carrasco, Steven Anderson, Grace Gallegos, James Randolph

Before (above) and after (right) photographs show just some of the improvements a 6S event can make to a laboratory. Identification and elimination of waste will make the future move to 878 easier, as well as help the planning of the space.

A 6S event was selected as the best candidate to prepare for this move and address these areas. A 6S event is a process and method for creating and maintaining an organized, clean, high performance workplace. A 6S workplace is safe, visually informative, and highly efficient. The event was conducted with the guidance of a SNL 6S black belt, Ruth Bargman Romero, and two trained greenbelts, Steven Anderson and Meliton Gonzales. Greenbelt training was completed shortly before the 6S event. The plan for improvements was completed on time in FY05 with results that exceeded expectations. The event took four days to complete with the help of seven employees from electronic fabrication. We also had help from Building 840 employees moving some of the large equipment out of the Magnetics lab. Improvements were made in all areas selected for the event.

Eleven pallets of various magnetic lab supplies and resources were identified as waste. The remaining lab resources were organized, straightened, and labeled to improve workflow and increase efficiency. Work cells were created to streamline product fabrication within the lab. The department has calculated that the 6S event will save our organization double the labor charges it took to get rid of the waste when compared to the cost to move the waste to the future location in building 878. Another benefit was increased capacity within our 878 location, including floor space and quality assurance and testing capabilities. Along with the recently purchased magnetic component tester, personnel also installed a microscope and two programmable thermal shock chambers. In addition, the event helped identify our future facility layout ahead of time.

This event has also put the Magnetics lab at the forefront of the department's ISO certification. According to ISO internal auditors; initially the Magnetics lab was identified as a “sore spot” and is now the example to follow. As a follow-up to the 6S event, the Magnetics lab has completed a value stream analysis on one of its critical processes, satellite transformer fabrication and testing. The lab identified 22 of the 37 steps as waste and are working on ways to eliminate these steps while preserving quality. Continual improvement will help identify areas of weaker operational performance and focus efforts on these areas. Housing the Magnetics lab under the same roof as the rest of Electronic Fabrication will streamline overall organizational cohesiveness.

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Mfg. S&T Personnel Move into Building 755

After over a year of planning, design, and construction, Building 755 is near completion and employees from the Mfg. S&T Center, along with personnel from two departments in the Advanced Information Systems and the Next Generation Monitoring Systems, are now resident. Located directly south of the Thunderbird Café, the building is surrounded by other General Plant Projects, Building 752 and Building 758, which is currently under construction. Building 755 could be called the "bridge" between Mfg. S&Ts two main facilities, Building 840 and Building 878. The building has approximately 5,000 sq. ft. of office space on each floor with 36 employees of the Mfg. S&T Center occupying the second floor of the building. Two managers moved into the building from Building 878, as did numerous technical staff and some administrative personnel representing five of the seven departments that make-up the Mfg. S&T Center. The second floor consists of single and double offices, a break room, work room, conference room and informal meeting room. This Building would not be possible without the funding, teamwork and assistance of many too numerous to mention. The building has received favorable reviews not only from the residents but others that have welcomed seeing a bit more color added to the Tech Area I campus.

Division Picnic at Isotopes Park

After much planning and preparation, the Division Picnic at Isotopes Park was a success. The weather was great and the turnout was amazing.

Food and refreshments were served during the game, so this gave attendees the chance to eat and mingle while they watched the game. Thanks to good planning, the food lines moved quickly and there was plenty of food for everyone.

The game was exciting; for his last official action as Vice President, Lenny Martinez threw the first pitch. Jorge Hernandez caught a foul ball with his bare hands! Isaiah Lucero, son of Monico Lucero, ran the Base Race against Orbit and won. As a special gift, every child who attended the game in the group was given an Orbit watch, compliments of Comcast. At the seventh inning, singing of the song, "Take Me Out to The Ballgame" was led by Carrie Devonshire, Jeremy Palmer, Tony Ontiveros, and Patrick and Ryan Meade, sons of Michael Meade. Thanks to the picnic coordinators who worked so hard to make this a fun night out for everyone!

My Favorite Summer Vacation

Bonaire is the eastern-most island of the ABC Netherlands Antilles, made up of Aruba, Curacao and Bonaire, in the "Dutch Caribbean." It is located about 40 miles north of Venezuela. Leave the image of high-rise buildings and commercialism behind and enjoy this remote island for a vacation of scuba diving, windsurfing, parasailing, sun tanning, and a host of other water sport activities, or simply enjoy the peace and quiet of a lazy afternoon siesta on the porch or beach.

Shannon and her mom, with their scuba gear

The most exciting aspect of Bonaire is the diving, specifically, the shore diving. I saw a variety of different fish, corals, creatures, and colorful marine life. I never had the opportunity to see a turtle, but they are around, especially in the summer. This diver's paradise is ranked number eight of the Caribbean's top ten sites for variety of fish species and the first in the world for shore diving. Furthermore, this entire Dutch island is dedicated as a marine park to preserve all of the wildlife and ocean life. There are wild Hazeldonkes (donkeys), goats, iguanas, flamingos, and many other birds protected by the marine park. The island also is known for its salt flats, which have operated since the 1700s and are the major source of income and employment on the island. If you ever have a yearning to go diving, snorkeling, or simply just unwind near the ocean without a lot of people, this is the place for you!

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2005-4929P